Watershed Branch Briefing
January 22, 2018
Oregon Marine Waters Listing

Deliberative Process / Ex. 5

Oregon Listing Background:

Considerations for 303(d) Listing Actions Related to Ocean Acidification

- Oregon waters: Data supporting a 303(d) listing must pertain to Oregon waters which include marine waters (territorial seas) three miles out from Oregon's coast.
- Marine pH criteria: Marine waters must fall between 7.0 and 8.5 pH units.
- Narrative criteria for aquatic life designated uses: Aquatic life designated use must not be impaired. Statewide Narrative Criteria that are relevant are listed below:
- OAR 340-41-0011 – Biocriteria. Waters of the State must be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.
- OAR 340-41-007:

  (1) Notwithstanding the water quality standards contained in this Division, the highest and best practicable treatment and/or control of wastes, activities, and flows must in every case be provided so as to maintain dissolved oxygen and overall water quality at the highest possible levels and water temperatures, coliform bacteria concentrations, dissolved chemical substances, toxic materials, radioactivity, turbidities, color, odor, and other deleterious factors at the lowest possible levels.

(10) The creation of tastes or odors or toxic or other conditions that are deleterious to fish or other aquatic life or affect the potability of drinking water or the palatability of fish or shellfish may not be allowed;

- Impairment: Marine aquatic life. The source of impairment does not need to be identified prior to listing. Source identification is part of the TMDL assessment, as is the determination of the remedy for the impairment.
- EPA Guidance: EPA's 2006 guidance and 2010 OA memo indicate that states should extrapolate data to similar waters and can use models, non-site specific data, trends, etc. to make listing decisions.

Oregon Listing History

- Oregon 2010 CWA 303(d) list submittal
- EPA solicited comments on proposed additions to the Oregon list in March, 2012.
- The Center for Biological Diversity (CBD) submitted comments as well as additional references, requesting EPA include all coastal waters as impaired on Oregon's list.
- EPA determined that there was insufficient evidence demonstrating non-attainment of Oregon's marine pH criteria and/or state-wide narrative criteria related to aquatic life designated uses to warrant listing any coastal waters as impaired or threatened.
- CBD filed a lawsuit challenging EPA's findings. EPA received a favorable decision on the case in February 2015.
- EPA's primary basis for its decision was that there were no studies or information about natural assemblages or indigenous aquatic species in ambient state waters showing impairment, or impaired conditions that were deleterious to aquatic life in ambient state waters. The majority of studies available at the time were based on laboratory experiments or hatcheries, or were from geographical locations that were not sufficiently relevant to Oregon water quality.
- The District Court gave EPA deference on its analysis of existing information and upheld EPA's decision. Specific points of EPA's rationale that the Court found reasonable were: (1) existing laboratory studies did not reflect natural conditions so could not be extrapolated; (2) Netarts Bay hatchery study could not be extrapolated to distant Oregon or Washington waters due to variable conditions in nearshore bays and coastal waters and because data were collected inside the hatchery building, not in ambient water; (3) and that although there were studies showing a link to aragonite saturation levels and biological effects, there were no existing studies showing impacts on indigenous aquatic species. It should be noted the Court was more skeptical as to why Netarts Bay should not be listed, but deferred to EPA's view that hatcheries were not representative of natural conditions.

- Oregon 2012 CWA 303(d) list submittal
- Oregon did not list for any impairments for parameters related to ocean acidification and only used pH data to respond to comments pertaining to ocean acidification.
- EPA partially approved and partially disapproved Oregon's 2012 list. EPA assessed all of the readily available data and information that Oregon failed to consider and proposed adding 332 waters to OR's list for a variety of parameters.
- EPA did not propose the addition of marine waters due to impairment of the aquatic life narrative related to ocean acidification. Instead, EPA solicited public comments specifically about ocean acidification and sought any additional data during our public comment period, which was open from December 16, 2016 to April 3, 2017.

- EPA received ocean acidification related comments from 4 stakeholders, including CBD, Oregon Wild, ODEQ and environmental staff from the Coquille Tribe. CBD supported the use of extrapolated data, submitted 22 pages of comments, as well as pH data and over 140 literature articles, and believed that at least 6 different locations off the Oregon coast should be listed. CBD proposed listing these sites for pH, as the pH levels recorded at these locations were at levels found to result in biological impacts. However, the pH measurements of all of the sites were well within the OR pH WQS, so EPA determined listing was not appropriate. Oregon Wild also supported the extrapolation of data from outside state waters to list state waters. ODEQ did not feel it was appropriate to use data from outside state waters, nor to use aragonite saturation information to interpret the narrative standard. Although not in its comment letter, ODEQ staff have also indicated that given the planktonic nature of pteropods, they did not think they should be used for listing even if collected within state jurisdiction. The environmental staff at the Coquille Tribe, speaking for himself, not on behalf of the Tribe, commented that this should be addressed through WQS and was not sure a listing would be effective, giving the potential for air sources outside ODEQ's jurisdiction.

Science Background: What has changed since 2010? The literature cited below represent the most current data and information available at this time. Many were referenced by CBD in their comment letter; EPA also reviewed additional literature published after the comment period ended.

<u>1. New research better quantifies the anthropogenic contribution to ocean acidification. Global carbon emissions are the dominant cause of ocean acidification.</u>

a. The anthropogenic increase in CO_2 in the atmosphere has caused a global average decline in surface ocean pH of 0.1 since the beginning of the industrial revolution and is expected to reduce average pH by another 0.3 units by the end of the century (Bednarsek et al. 2014).

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a. Existing pH levels fall within the allowable range of OR WQS, but pH levels well within this range are documented to cause extensive biological damage to a variety of organisms (Weisberg et al., 2016).
b. Several studies have shown that the aragonite saturation state is a better indicator of OA than pH (Waldbusser et al., 2014; Waldbusser et al., 2015).
c. In supersaturated conditions, where the aragonite saturation is greater than one, pteropods and other shell-building organisms exhibit no signs of shell dissolution. Near the aragonite saturation value of 1, organisms begin to exhibit signs of stress. Under an aragonite saturation value of 1, organisms experience major damage (Weisberg et al., 2016).
d. Waters with an aragonite saturation value of 1 or less are generally considered to be corrosive and field studies (Bednarsek et al. 2014) and laboratory experiments (Busch et al., 2014) demonstrate this leads to dissolution of organisms shells. Recent research has determined a "shell dissolution threshold" of 1.1, above which signs of shell stress are not observed. At the threshold of 1.1, approximately 50% of pteropods are affected by dissolution. Below a saturation state of 0.8 dissolution becomes even more severe (Bednarsek et al., 2017a, 2017b). Other research has documented saturation states of 1.7 being linked to commercial production failures of larval oysters (Barton et al., 2012).
e. The "shell dissolution threshold" of 1.1 at which 50% of pteropods are affected generally occurs around a pH of 7.8-7.85, which is well within the range of the Oregon WQS (Bednarsek et al., 2017a).
f. Aragonite saturation values of 1 or lower have been repeatedly observed in the marine waters of Washington and Oregon, in the coastal ocean (Feely et al., 2008; Harris et al., 2013) and the estuarine water

of Puget Sound and the Columbia River (Feely et al., 2010, 2016; Reum et al., 2014), while pH values remain well within the criteria.

g. Researchers argue that pteropod shell dissolution should be used as an ecological indicator and early indicator of ocean acidification conditions. Using a screening methodology for indicators of marine ecological integrity, shell dissolution scored very highly compared to other potential indicators (Bednarsek et al., 2017a).
h. Pteropod dissolution may signal similar declines in the health and productivity of other taxa with similar biology, ecology and distribution, and therefore ecosystem level implications (Bednarsek et al., 2017a).

<u>3. Local research details why we are seeing effects here first. Waters in the Pacific Northwest are particularly vulnerable to ocean acidification because of coastal upwelling and ocean currents.</u>

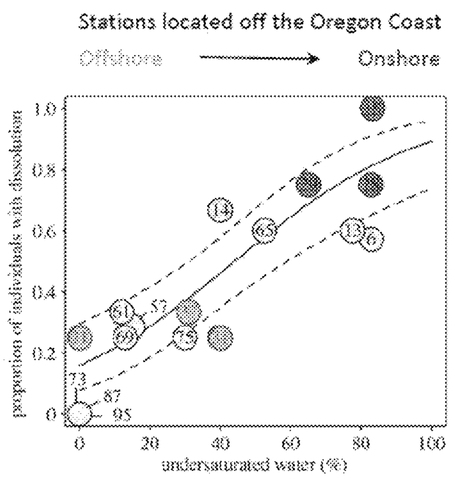
a. The waters of the Pacific Northwest, including Oregon, are vulnerable to ocean acidification, because winds that blow southward during the spring and summer months push surface waters away from the coastline. As the surface waters are displaced, the deep waters rich in CO_2 and low in dissolved oxygen are pulled to the surface in a process known as upwelling (Feely et al., 2008; Juranek et al., 2009; Harris et al., 2013).
b. These upwelling events primarily occur in the summer and early autumn months, and last for approximately one to five weeks (Bednarsek et al., 2014).
c. When these events occur the aragonite saturation state decreases and the chance of adverse impacts on aquatic life increases (Bednarsek et al., 2014).
d. Pteropods do not show adaptation to OA events with increased exposure, so are most vulnerable in areas of frequent and prolonged corrosive events (Bednarsek et al., 2017b).
e. Although upwelling has always been present along the west coast of the U.S. due to the prevailing northerly winds, the corrosiveness of upwelled waters has increased significantly since pre-industrial times (Bednarsek et al., 2014) due to increased carbon emissions into the atmosphere from fossil fuel combustion and its impact on ocean waters.
f. The waters that upwell along the west coast are relatively old and have a signature roughly 50 years old, depending on the exact depth at which the upwelling occurs, which varies with the strength and wind angle.
g. Impacts to organisms along the coast due to aragonite saturation state <1 currently are indicative of the “tip of the iceberg” with predicted further decrease in aragonite saturation state from emissions that already occurred over the last 50 years.

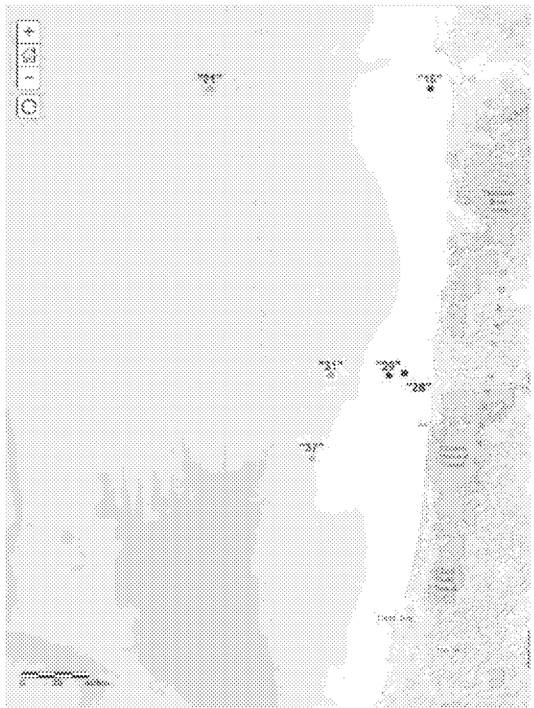
4. There is now biological data from wild, native population assemblages available. Bednarsek et al., 2014, supplemental data provided by UW/NOAA, and others have shown shell dissolution of pteropods off the coast of Oregon and that shell dissolution owing to ocean acidification has doubled since pre-industrial conditions and is on track to triple by 2050.

a. In 2014, Bednarsek et al. published a widely publicized study on the shell dissolution of pteropods off the coast of Washington, Oregon, and California.
b. Pteropods are an important prey group for ecologically and economically important fishes, bird, and whale diets (Bednarsek et al., 2014)
c. For Oregon, the 2014 Bednarsek et al. pteropod samples were collected at stations ranging from 6.5 miles to 85 miles from the Oregon shoreline (approximately 3.5 to 82 miles outside state waters.)
d. The stations with the highest proportion of individuals exhibiting signs of dissolution were located closest to shore (see figures below.)
e. The study found that 53% of onshore and 24% of farther offshore pteropods had severe dissolution damage.
f. The authors estimated that the incidence of severe pteropod shell dissolution owing to anthropogenic OA has doubled in near shore habitats since pre-industrial conditions across the study area and is on track to triple by 2050.
g. Unpublished data from Bill Peterson (NOAA, NW Fisheries Science Center) show a decline in pteropods at a station located 9.1 km (5.65 mile from the Oregon shore; approximately 2.65 miles outside state waters.)

h. Recent observed declines in pteropod populations of one species on the continental shelf of Vancouver Island correspond with demonstrated high occurrences of severe shell dissolution, although a definitive link has not been made. Two other pteropod species exhibited different trends, however, so no sustained and consistent downward trend in total pteropod abundance/biomass has been recorded. (Mackas and Galbraith, 2012.)

i. Feely et al., 2015, data demonstrate an aragonite saturation state of less than 1, which is corrosive to pteropods, in 73% of observations in state waters.





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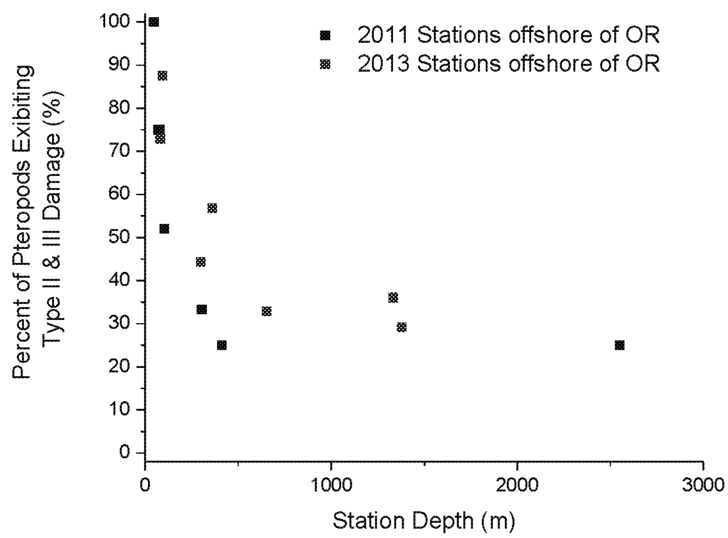
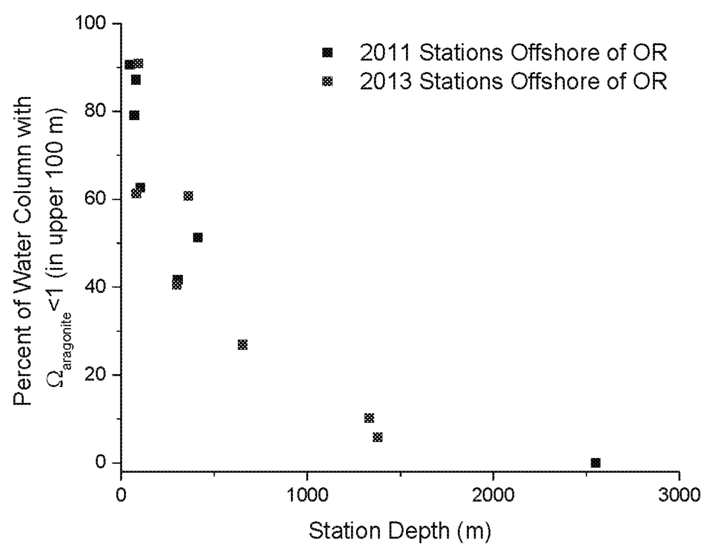
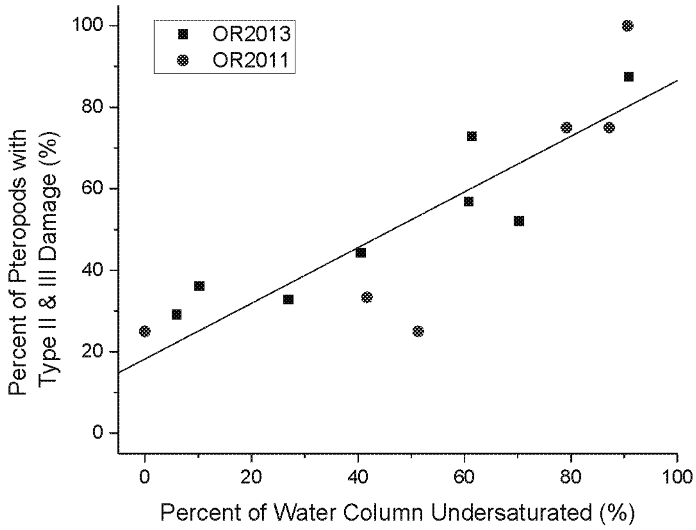
j. The graphs below show the relationship between pteropod dissolution and station depth, percent of water column with aragonite saturation less than 1 and station depth, and dissolution of pteropods and percent of water column undersaturated.


2011 Stations offshore of OR
2013 Stations offshore of OR
Percent of Pteropods Exibiting Type II & III Damage (%)
Station Depth (m)
0
10
20
30
40
50
60
70
80
90
100
0
1000
2000
3000


2011 Stations Offshore of OR
2013 Stations Offshore of OR
Percent of Water Column with $\Omega_{aragonite}$<1 (in upper 100 m)
Station Depth (m)
0
20
40
60
80
100
0
1000
2000
3000



k. Several additional lab and field studies have shown impacts to shellfish from corrosive conditions.
   1. A number of studies document a close positive correlation between the rate of calcification and the aragonite saturation state. As the aragonite saturation state decreases, so does the rate of calcification (Feely et al., 2012)
   2. Mollusks (such as mussels, clams, and oysters) have been shown to be sensitive to ocean acidification, and both early life stages and adults have shown reduced calcification, growth, and survival when exposed to corrosive conditions (e.g., aragonite saturation less than 1) (Nature Climate Change 10.1038)
   3. Hatchery and laboratory studies have shown that oyster larvae experience conditions detrimental to their development and growth at an aragonite saturation level of 1.7 (Waldbusser et al., 2013).
   4. Laboratory studies by Miller et al., 2016, demonstrate impacts on early stages of Dungeness crabs, including delays in hatching at a pH of 7.1, and significantly reduced zoeal survival at a pH of 7.5 and below.
   5. Bednarsek et al., 2016, recorded increased pteropod mortality with increased dissolution.
   6. Recent studies by both Bednarsek et al., 2016, and Lischka *et* al., 2011, document cumulative effects of decreased pH, deoxygenation and increased ocean temperatures which negatively impacted survivability of pteropods.

Discussion: Deliberative Process / Ex. 5

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g. Feely et al., 2015 data demonstrate an aragonite saturation state of less than 1, which is corrosive to pteropods, in 73% of observations in Oregon State Waters.

h. The calculated aragonite saturation state during the upwelling months (July and August) off of Newport, OR between 1998 – 2016 were generally less than 1 (CCIEA Team 2017).

i. Feely et al., 2012 documented 0.34% decrease per year in aragonite saturation state in near surface waters over a 14-year period.

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Region 10 Recommendation:

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